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Disease activity indexes in rheumatoid arthritis; a prospective, comparative study with thermography

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SUMMARY There are many difficulties associated with the assessment of disease activity in rheumatoid arthritis. Infrared thermography has been used to quantify joint inflammation. The heat distribution index (HDI) is reproducible, sensitive, quantifiable, and not subject to circadian variation or interobserver error. In this study the HDIs for both elbows, wrists, knees, and ankles were summated and compared with other parameters of disease activity. There were 167 sets of observations in 20 patients with classical, seropositive, rheumatoid arthritis followed up over 12 months. There was a significant correlation ($p < 0.001$) for thermography with the Ritchie articular index, Mallya score, grip strength, morning stiffness, erythrocyte sedimentation rate, and pain score. Significant correlations ($p < 0.05$) for thermography with these parameters were found in individual patients. The summated HDI is a suitable, objective method for the assessment of response to therapy in patients with rheumatoid arthritis.

The need for reliable, reproducible, and quantitative assessments of rheumatoid activity has resulted in the use of many methods for patient evaluation. These include morning stiffness,¹ visual analogue pain score,² grip strength,³ the Ritchie articular index,⁴ the Steinbrocker functional class,⁵ combined proximal interphalangeal joint circumference,⁶ and the Lansbury articular index.⁷ Many laboratory parameters have also been shown to reflect disease activity. These include erythrocyte sedimentation rate, C-reactive protein, blood haemoglobin, platelets, serum histidine, serum sulphhydryl, and plasma viscosity.^{8,9} By combining variations of these subjective and objective measures, indexes have been developed.^{7,8,10}

Thermography has been shown to be a reproducible and sensitive method for measuring disease activity in medium sized joints.¹¹ The thermographic index (TI) is a reflection of mean surface temperature. Improvements in the TI can be shown with oral steroids, non-steroidal anti-inflammatory drugs,¹² intra-articular steroids,¹³ and penicillamine.¹⁴ The heat distribution index (HDI) reflects the pattern

and spread of temperature over a joint. The clinical assessment of joint inflammation correlates better with the HDI than with the TI.¹⁵ This study combined the HDIs from a number of medium sized joints and set out to correlate thermography with other assessments of rheumatoid activity.

Patients and methods

PATIENTS

Twenty adult outpatients with classical, seropositive, rheumatoid arthritis (American Rheumatism Association criteria) were assessed at four to eight weekly intervals over a 12-month period. All patients were on second-line drug therapy. Twelve were followed up from the start of the second-line drug treatment, three after four months' treatment, two after eight months' treatment, and three after 12 months' treatment. This provided a wide range of rheumatoid activity for evaluation. At each visit all of the observations were performed in the afternoon, on the same day of the week, by the same clinician.

ASSESSMENTS

At each visit the following observations were obtained: (1) morning stiffness (MS) recorded in minutes; (2) pain score (PS) represented by a 100 mm horizontal line marked 'no pain' on one end and

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Table 1 Patient details – mean (range)

Age (years)	53.1 (29–69)
Sex, M:F	6:14
Disease duration (years)	6.0 (1–25)

Table 2 Thermography correlations

Parameter	r	p
Morning stiffness	0.394	<0.001
Pain score	0.255	<0.001
Grip strength	-0.462	<0.001
Articular index (AI)	0.685	<0.001
Partial AI	0.535	<0.001
Mallya score	0.547	<0.001
Hb	0.102	>0.1
ESR	0.280	<0.001
CRP	0.084	>0.1

'pain could not be worse' on the other. Patients were asked to represent the severity of their pain by marking the line which was then measured in millimetres; (3) grip strength (GS) measured with an anaeroid manometer attached to a special cuff which had been inflated to 30 mm of mercury. Three readings were taken from each hand and the mean of the six readings was recorded, (4) the articular index (AI) calculated in accordance with the method of Ritchie *et al.*;⁴ (5) the haemoglobin (Hb) measured by Coulter count; (6) the erythrocyte sedimentation rate (ESR) estimated by Westergren's method; (7) the total Mallya score¹⁰ calculated from these measurements; (8) the C-reactive protein (CRP) measured by rate nephelometry (Beckman

ICS Immunochemistry System) and expressed as mg/dl. (SI conversion: mg/dl×10=mg/l.)

THERMOGRAPHY

Infrared thermography was carried out in a draught-free room with the ambient temperature controlled at 20.5±0.5°C and humidity 50±10%. Subjects were seated with their upper and lower limbs exposed for 15 minutes stabilisation before thermograms were taken. An AGA 680M thermovision system was used with an OSCAR interface to record the thermograms on magnetic tape as a digital image for later computer analysis. The camera was placed at a distance of 1.0 m to obtain a thermogram of the anterior views of the wrists in a neutral position, lateral views of the knees and elbows flexed to 90°, and lateral views of the ankles in a neutral position. The HDI was obtained for each of these joints by the method described by Salisbury *et al.*¹⁵ Abnormal values for the eight joints assessed were summated to produce a combined HDI.

PARTIAL ARTICULAR INDEX

This figure was calculated from the Ritchie articular index for the eight joints observed by thermography.

STATISTICAL ANALYSIS

The observations were correlated with each other by the product moment coefficient correlation test.

Results

Patient details are shown in Table 1. One hundred and sixty seven sets of observations were obtained.

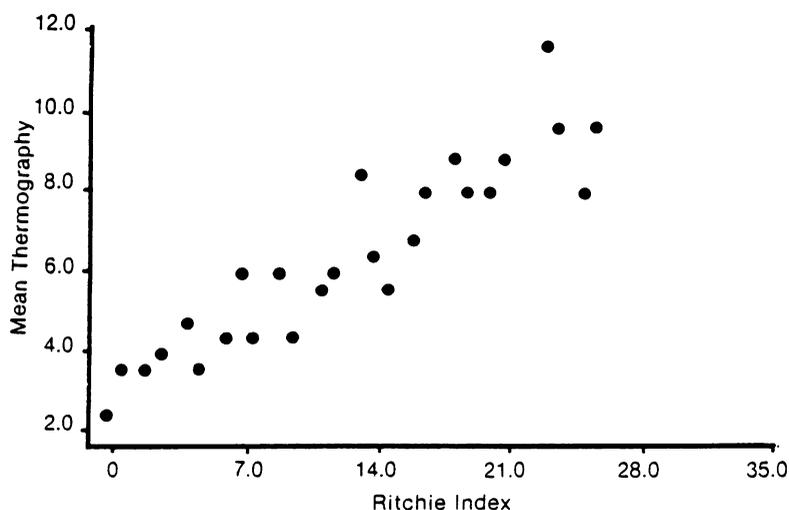


Fig. 1 Correlation between mean thermographic HDI and Ritchie articular index.

Table 3 *Articular index correlations*

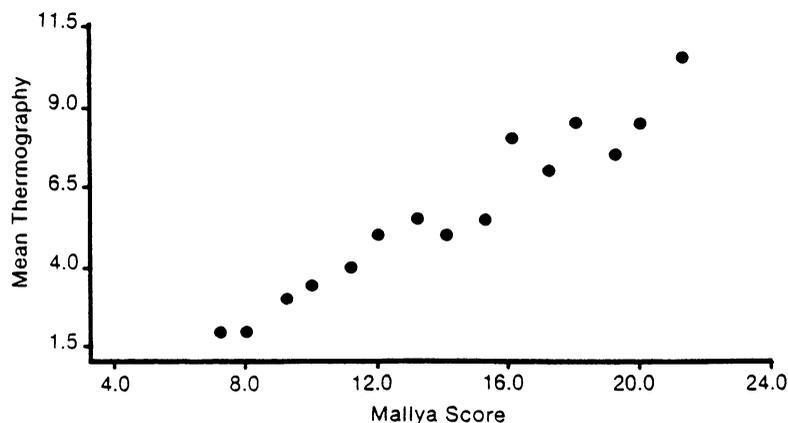
Parameter	r	p
Morning stiffness	0.559	<0.001
Pain score	0.559	<0.001
Grip strength	-0.399	<0.001
Thermography	0.685	<0.001
Partial AI	0.856	<0.001
Mallya score	0.828	<0.001
Hb	-0.115	>0.1
ESR	0.427	<0.001
CRP	0.166	<0.05

Table 4 *Mallya score correlations*

Parameter	r	p
Morning stiffness	0.663	<0.001
Pain score	0.745	<0.001
Grip strength	-0.363	<0.001
Thermography	0.547	<0.001
Articular index (AI)	0.828	<0.001
Partial AI	0.728	<0.001
Hb	-0.268	<0.001
ESR	0.580	<0.001
CRP	0.261	<0.001

There was a significant correlation ($p<0.001$) of thermography with AI, partial AI, Mallya score, grip strength, morning stiffness, ESR, and pain score (Table 2). CRP showed a better correlation with both articular index ($p<0.05$) (Table 3) and Mallya score ($p<0.001$) (Table 4) than with thermography.

The strong clinical relationship of thermography with the Mallya score and Ritchie AI can be seen in Figs 1 and 2. For these figures the mean thermographic index at each AI and Mallya value was calculated from the 167 pairs of observations on the scattergrams.

Fig. 2 *Correlation between mean thermographic HDI and Mallya score.*

Seven of the 20 patients were selected for further analysis on the basis of a large change in disease activity over the 12-month period of follow up. A change in AI greater than 15 was used for this selection. Table 5 confirms the significant correlation ($p<0.05$) of thermography with AI and Mallya score in six of the seven patients. Significant correlations ($p<0.05$) were also noted with grip strength (five patients), pain score (four patients), and ESR (four patients).

Discussion

There are many difficulties associated with the use of subjective or semiobjective methods to assess disease activity in rheumatoid arthritis.^{3,6} In particular, laboratory measurements are objective but many of these, such as ESR,¹⁶ have a circadian variation. Unlike other thermographic parameters the thermographic HDI offers objective data with no circadian variation.¹⁵

There is a poor degree of correlation between different observers with the AI.⁴ Mallya and Mace¹⁰ attempted to overcome some of these problems by developing a score using multivariate analysis. However, the Mallya score also includes an AI. The combined HDIs of eight medium sized joints correlate well with both of these methods (Figs 1 and 2). Thermographic quantification of synovitis removes the interobserver variability, by standardised computer analysis of the abnormal thermographic pattern.

The reproducibility and sensitivity of thermography has been shown to be adequate for measuring disease activity in medium sized joints but unsatisfactory when measuring disease activity in small joints.¹¹ The eight joints assessed thermographically in this study were chosen for this reason,

Table 5 Correlations with thermography in the seven patients who had an overall change of 15 or greater in the Ritchie articular index during the 12-month assessment period

Patient	Pain score	Grip	AI	ESR	Mallya	Partial AI	Number of assessments
1	0.8447 (p<0.01)	-0.7932 (p<0.02)	0.9328 (p<0.001)	0.0344 NS	0.9001 (p<0.001)	0.5639 NS	9
2	0.7420 (p<0.01)	-0.8614 (p<0.001)	0.8610 (p<0.001)	0.7134 (p<0.01)	0.8086 (p<0.001)	0.9010 (p<0.001)	13
3	0.8334 (p<0.02)	-0.8891 (p<0.01)	0.7565 (p<0.05)	0.5839 NS	0.8357 (p<0.01)	0.7696 (p<0.05)	8
4	0.6922 (p<0.05)	-0.8901 (p<0.01)	0.8801 (p<0.01)	0.7162 (p<0.05)	0.8750 (p<0.01)	0.7158 (p<0.05)	9
5	0.2977 NS	-0.8141 (p<0.05)	0.7406 NS	0.7761 (p<0.05)	0.8387 (p<0.02)	0.7740 (p<0.05)	7
6	0.7103 NS	-0.4982 NS	0.8984 (p<0.01)	0.7729 (p<0.05)	0.8684 (p<0.02)	0.7610 (p<0.05)	7
7	0.4703 NS	-0.6337 NS	0.7272 (p<0.05)	0.4038 NS	0.5843 NS	0.6233 NS	9

NS=not significant.

and because they are easily accessible and usually have synovial inflammation in rheumatoid arthritis. From the area of joint surfaces used to develop the Lansbury index they contribute to over 40% of the total possible joint inflammation.¹⁷

The major problem with thermography is the requirement of a temperature controlled room for the 15 minutes patient cooling period. This can be overcome by cooling in a separate area, while the actual HDIs for the eight joints can be obtained in five minutes. Thermographic assessment is objective, reproducible, accurate, and non-invasive.

The significant correlations with AI, Mallya score, GS, morning stiffness, ESR, and PS observed in Table 2 confirm the relevance of using a combined thermographic HDI for the assessment of rheumatoid joint disease. Prospectively, as seen from Table 5, this method can be used to assess a patient's progress without the variability which can be associated with other measures.^{3 4 16} Thermography is non-stressful for the patient and appears to improve compliance during drug studies. The thermographic method is extremely suitable for the assessment of response to therapy in patients with rheumatoid arthritis.

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